ABSTRACT

A spin valve device including at least one stack of layers having an electrically conductive, nonmagnetic layer placed between first and second magnetic layers having a magnetization with a certain direction. At least one of the first and second magnetic layers has directly, at an interface with the nonmagnetic layer, a specular reflection for conduction electrons dependent on an orientation of the spin of the conduction electrons relative to a magnetization direction in the first and second magnetic layers.

REMARKS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-12 are pending in the present application and have been amended by the present amendment.

In the outstanding Office Action, the drawings were objected to; the abstract was objected to; Claims 2, 3 and 10 were objected to; Claims 1, 3-6 and 9-11 were rejected under 35 U.S.C. §102(b) as anticipated by Swagten et al; and Claims 1-3, 5-6 and 8 were rejected under 35 U.S.C. §103(a) as unpatentable over Singleton et al.

Regarding the objection to the drawing, Figure 1 has been labeled "PRIOR ART" as requested by the Examiner. A separate letter requesting approval of this drawing change is being submitted to the draftsman.

Further, regarding the objection to the abstract, a new abstract has been added to corresponding with standard U.S. patent practice. Accordingly, it is respectfully requested the objection to the abstract be withdrawn.

Regarding the objection to Claims 2, 3 and 10, each of these claims have been amended to include the proper Markush group terminology. Accordingly, it is respectfully requested this objection also be withdrawn.

Claims 1, 3-6 and 9-11 stand rejected under 35 U.S.C. §102(b) as anticipated by Swagten et al. This rejection is respectfully traversed.

Amended Claim 1 is directed to a spin valve device including at least one stack of layers having an electrically conductive, nonmagnetic layer placed between first and second magnetic layers having a magnetization with a certain direction. Further, at least one of the first and second magnetic layers has directly at an interface with the nonmagnetic layer, a specular reflection for conduction electrons dependent on an orientation of the spin of the conduction electrons relative a magnetization direction in the first and second magnetic layers.

In a nonlimiting example, Figure 2 illustrates at least one stack of layers including an electrically conductive, nonmagnetic layer (NM) placed between first (R) and second (R') magnetic layers having a magnetization with a certain direction. Further, at least one of the first and second magnetic layers (R, R') has directly at an interface with the nonmagnetic layer (NM), a specular reflection for conduction electrons dependent upon an orientation of the spin of the conduction electrons relative to a magnetization direction in the first and second magnetic layers.

On the contrary, Swagten et al disclose a spin valve device between two insulating layers, e.g., NiO layers (see Figure 1). The specular reflection appears between the lower NiO layer and the lower magnetic layer. The upper NiO layer does not generate specular reflection for technical reasons explained in the end of Swagten et al. That is, the specular reflection at the interface with the nonmagnetic layer is not generated by the magnetic layers of the spin valve, but rather the specular reflection at the interface with the nonmagnetic layer is generated by the lower NiO layer at the interface with the magnetic layer. In fact, Swagten et al belongs in the group of devices discussed in the background art mentioned in the specification at the last lines of page 2 and the first lines of page 3. In more detail, this

section discloses that "thin oxide layers increasing the specular reflection of the electrons" can be added to spin valves.

This differs from the claimed invention in which the specular reflection does not result from an addition, but is inherent to the first and second magnetic layers because of the material used (such as the material used in dependent Claim 2).

Accordingly, it is respectfully submitted independent Claim 1 and each of the claims depending therefrom patentably define over Swagten et al.

Claims 1-3, 5, 6 and 8 stand rejected under 35 U.S.C. §103(a) as unpatentable over Singleton et al. This rejection is respectfully traversed.

As noted above, amended Claim 1 recites that the at least one of the first and second magnetic layers has directly at an interface with the nonmagnetic layer, a specular reflection for conduction electrons dependent on an orientation of the spin of the conduction electrons relative to a magnetization direction and the first and second magnetic layers. On the contrary, Singleton et al teach specular scattering layers 101, 105 which are not directly at an interface with a nonmagnetic layer.

Accordingly, it is respectfully requested this rejection also be withdrawn.

Consequently, in light of the above discussion and in view of the present amendment, the present application is believed to be in condition for allowance and an early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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IN THE SPECIFICATION

Page 3, lines 2-6, amend the paragraph to read as follows:

The resistance values obtained at present are approximately 8 to 15% at ambient temperature, the absolute sheet resistance change between the parallel and antiparallel configurations being approximately 2 to 2.50 [Ω] Ω/square. These structures are suitable for an information storage density of 50 Gbits/inch^2, i.e. approximately 8 Gbit/cm^2.

Page 4, lines 23-26, please amend the paragraph to read as follows:

Figs. 4A, 4B and 4C show the variations of certain magnitudes ([sheet] resistance/square, absolute magnetoresistance, relative magnetoresistance), inherent in the first variant as a function of the thickness of the separating, nonmagnetic layer.

Page 4, lines 30-33, please amend the paragraph to read as follows:

Figs. 6A, 6B, 6C and 6D show the variations of certain magnitudes ([sheet] resistance/square, absolute magnetoresistance, relative magnetoresistance and [sheet] conductance/square) for different specular reflection contrasts as a function of the thickness of the separating, nonmagnetic layer.

Page 5, lines 2-5, please amend the paragraph to read as follows:

Figs. 9A, 9B and 9C show the variations of the [sheet] resistance/square, absolute magnetoresistance and relative magnetoresistance as a function of the thickness of the nonmagnetic layer for the second variant of the invention.

Page 6, lines 32-34, please amend the paragraph to read as follows:

Figs. 4A, 4B and 4C show the [sheet] resistance/square variations (4A), the relative magnetoresistance $\Delta R/R$ (4B) and the absolute [sheet] magnetoresistance/square (4C) as a function of the thickness t of the nonmagnetic layer in [nanometers] nanometers.

Page 7, lines 2-10, please amend the paragraph to read as follows:

Thus, these drawings show the transport properties which can be obtained in the ideal case, where the reflection is perfectly specular for one category of electrons and totally diffuse for the other category of electrons. The relative magnetoresistance amplitude can be extremely high in this case, several dozen per cent compared with 10 to 15% in the best, presently available spin valves. The absolute magnetoresistance amplitude is particularly high in view of the high resistance of these layers. It can reach several dozen [ohm^2] Ω/square, whereas it is approximately 2 to 3 ohms in the best existing spin valves.

Page 8, lines 30-41, please amend the paragraph to read as follows:

This second variant makes it possible to establish whether a material R has spin-dependent reflection effects at the interface R/NM. It is in fact sufficient to implement a structure in the form substrate (e.g. Si)/Ta, 5 nm/$Ni_{80}Fe_{20}$, 4 nm/$Co_{90}Fe_{10}$, 1 nm/Cu 2.5 nm/R 20 nm and then measure the resistance of said structure in a field varying from -100 Oe to +100 Oe, in which it is certain that the magnetization of the NiFe/CoFe layer has changed. If a magnetoresistance effect linked with the passage from parallelism to antiparallelism of the magnetizations of F and R, then the material R has a spin-dependent reflection which can be quantified with the aid of a semiclassical theory. However, if no resistance change has been observed, then the material R can have specular reflection, but the latter is not dependent on the electron spin.

Page 9, lines 31-37, please amend the table to read as follows:

Volume parameters:

Material	[Average] mean free path (nm) spin ↑	[Average] mean free path (nm) spin ↓
NiFeCr	0.4	0.4
$Ni_{80}Fe_{20}$	7	0.7
$Co_{90}Fe_{10}$	9	0.9
Cu	12	12

Page 10, lines 31-35, please amend the table to read as follows:

Volume parameters:

Material	[Average] mean free path (nm) spin ↑	[Average] mean free path (nm) spin ↓
NM (Cu)	12	12
$Co_{90}Fe_{10}$	9	0.9

IN THE CLAIMS

--1. (Amended) [Spin] A spin valve device comprising:

at least one stack of layers [comprising] including an electrically conductive, nonmagnetic layer [(NM)] placed between [a] first [(R)] and [a] second [(R', F)] magnetic layers[, the first (R) and second (R', F) magnetic layers] having a magnetization with a certain direction, [said device being characterized in that]

wherein at least one of said first and second magnetic layers [(R, R', F)] has directly[,] at [the] an interface with the nonmagnetic layer [(NM)], a specular reflection for [the]

conduction electrons dependent on [the] an orientation of the spin of the conduction electrons relative to [the] a magnetization direction in the first and second magnetic [layer or] layers.

2. (Amended) [Device] The device according to claim 1, wherein the magnetic [layer or] layers [(R, R')] having [a] the specular reflection [are made from] include a material [taken from within the group including] selected from the group consisting of 1) ferromagnetic oxides based on [iron and/or nickel and/or cobalt and/or chrome or] at least one of iron, nickel, cobalt and chrome, and 2) ferromagnetic nitrides based on [iron and/or nickel and/or cobalt] at least one of iron, nickel and cobalt.

3. (Amended) [Device] The device according to claim 1, wherein the electrically conductive, nonmagnetic layer [(NM) is of a metal taken from within the group including] includes a material selected from the group consisting of copper, silver and gold.

4. (Amended) [Device] The device according to claim 3, wherein the electrically conductive, nonmagnetic layer [(NM)] has a thickness less than approximately 10 nm.

5. (Amended) [Device] The device according to claim 1, [also] further comprising an anti-ferromagnetic layer adjacent to at least one of said first and second magnetic layers [(R, R')].

6. (Amended) [Device] The device according to claim 1, wherein the at least one stack is deposited on a substrate [(S)].

7. (Amended) [Device] The device according to claim 1, wherein the at least one stack is covered by a protective layer [(P)].

8. (Amended) [Device] The device according to claim 1, wherein both of the first [(R)] and second [(R')] magnetic layers [in each case] have said electron specular reflection.

9. (Amended) [Device] The device according to claim 1, wherein the first magnetic layer [(R)] has an electron specular reflection, the second magnetic layer [(F)] does not [having] have said specular reflection, but [having] has a diffusion of the conduction electrons dependent on the orientation of the spin of the conduction electrons relative to the magnetization direction in said second magnetic layer [($\overline{F}$)].

10. (Amended) [Device] The device according to claim 9, wherein the second magnetic layer [(F)] having [a] the diffusion of the conduction electrons [is a material taken from within the group including] includes a material selected from the group consisting of transition metals, and alloys based on [nickel and/or iron and/or cobalt] at least one of nickel, iron and cobalt.

11. (Amended) [Device] The device according to claim 10, [also] further comprising a ferromagnetic layer adjacent to the second magnetic layer [(F)].

12. (Amended) [Device] The device according to claim 1, wherein said at least one stack of layers includes a first stack of layers [(K) comprises a] having the first electrically conductive, nonmagnetic layer [(NM)] placed between [a] the first [magnetic layer (R)] and [a] second magnetic [layer (F)] layers and a second stack [(K')] of layers [comprising a first]

having a second electrically conductive, nonmagnetic layer [(NM')] placed between [a first] the second magnetic layer [(F)] and a [second] third magnetic layer [(R')], [the second magnetic layer of the first stack (K) coinciding with the first magnetic layer of the second stack (K')], said second magnetic layer [(F)] having a diffusion of the conduction electrons dependent on the orientation of the spin of the conduction electrons, the first magnetic layer [(R)] of the first stack [(K)] and the [second] third magnetic layer [(R')] of the second stack [(K')] having in each case a specular reflection of the conduction electrons dependent on the orientation of said conduction electrons.--